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INSECTICIDAL USES OF NICOTINE AND TOBACCO

A condensed Summary of the Literature, 1690-1934

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INTRODUCTION

In September 1936 the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture issued Part II of "A Bibliography of Nicotine" under the subtitle "The Insecticidal Uses of Nicotine and Tobacco," by N. E. McIndoo, R. C. Roark, and R. L. Busbey. This Part II was issued as E-392, a mimeographed circular of 628 pages in three sections, containing 2,497 abstracts, which include the published information from 1690 to the fall of 1934. In trying to compress the most important data contained in the original 628 pages into this brief summary, the writer had a difficult task, chiefly because much of the information was fragmentary and contradictory, and the information on a given species was often widely scattered under two or three different scientific names.

In the present summary the information on the most important species that had been controlled more or less successfully before 1934 by the use of nicotine is stated as briefly as possible. Nicotine has been recommended^{1/} against a wide range of insects which are here grouped by orders, families, and species. The unversed reader might infer from this large list of insects that nicotine is a universal insecticide and that it is the most effective means of controlling the majority of the species discussed. To the contrary, nicotine has a limited use and plays a minor part in the control of many of the species mentioned in this review. Prior to 1934 nicotine was the best remedy known for certain species, but more recently other insecticides, particularly oil sprays and rotenone, have taken that place. To emphasize the importance of the species mentioned, the present circular includes the geographic distribution of many of them, the countries being arranged in the chronological order of the references.

HISTORY OF INSECTICIDAL USES OF TOBACCO AND NICOTINE

I. CLASSES OF INSECTICIDES

Insecticides are generally divided into three classes, based on the way they are applied to the insects. The contact insecticides comprise both liquids and solids. In the literature on nicotine the liquids are described as washes, tobacco water, infusions, decoctions, tobacco juice, extracts, and dips; and the solids, as powders and dusts. The fumigants are called smokes, fumes, or vapors, and are produced by burning or heating tobacco in solid or liquid form. When the liquids

^{1/} This should be understood throughout this summary to mean that the writers of the various articles listed in the bibliography recommended the specified treatments. No appraisalment by the Department of Agriculture is implied in citing the various preparations mentioned or statements regarding them.

and solids are applied so as to be taken into the stomach they are called stomach poisons. Tobacco and nicotine are used chiefly as contact insecticides and fumigants, and very little as stomach poisons.

Contact Insecticides

Tobacco was first utilized in 1690 as an insecticide, a wash having been applied to pear trees in France to control the pear lacebug. Tobacco water and tobacco powder were recommended in 1763 as a remedy for plant lice in France. In some cases tobacco dust was used successfully in 1773 against aphids and the red spider in England. In 1800 tobacco was in common use as an insecticide in England. Tobacco dust was blown from a powder puff, such as hairdressers used, upon aphid-infested trees, or Scotch snuff was merely dusted upon the insects. Infested leaves were also dipped in a strong tobacco infusion. Tobacco was first used as an insecticide in America at Albany, N. Y., in 1814, tobacco water having been applied against sucking insects. In the same year a force pump was employed to squirt a decoction upon caterpillars and a leaf roller in England. Tobacco juice was recommended in 1829 for the woolly aphid in England. Tobacco extract was first mentioned in 1859, but in the 1880's and 1890's it was commonly referred to in the literature. The word "dip" was first mentioned in 1896, and later it was frequently used.

Fumigants

In 1773 tobacco was put in an iron pipe which was heated and the smoke from it was blown onto infested plants by the use of a bellows. Another type of fumigating bellows was used and described in the same year. In 1800 a pair of bellows was used to force smoke under a tent which had been put over a nut tree infested with aphids. In 1828 a tent on wheels to go over a grapevine trellis was recommended in America, and in 1839 growers were advised to burn paper saturated with tobacco extract under a tent stretched over peach and nectarine trees to kill aphids. In 1851 a fumigator which burned tobacco and ejected the smoke was invented. In 1879 a specially constructed hood was invented and used in England. This was put over rose bushes infested with aphids, and tobacco smoke was conducted by pipes into the hood. In 1902 the Geneva fumigator was employed to fumigate aphids.

Turning to the use of tobacco indoors, it was becoming the custom to use tobacco smoke in greenhouses as early as 1825, and in 1877 mention is found of putting tobacco juice on a hot metal plate in order to make a dense smoke in a box containing aphid-infested plants. In 1884 tobacco extract was put on the heating pipes in a greenhouse, and in 1895 red-hot bars and in 1897 hot bricks were used to vaporize the extract. The method of dropping the liquid on hot metal was the forerunner of the present aerosol method. The most common method of fumigating with tobacco, however, was to evaporate the tobacco extracts in shallow vessels over charcoal, kerosene, or alcohol stoves.

Stomach Poisons

Not until recently did writers discuss how nicotine affects insects, and consequently their papers do not mention nicotine or tobacco as stomach poisons. In 1911 it was observed that the ingestion of leaves treated with nicotine caused characteristic convulsions of flea beetle larvae, which died shortly afterward. Larvae of vine moths and beetles were partially controlled in 1913 as a result of their eating nicotine-treated leaves. Nicotine was fed to honeybees in 1916, and the symptoms of poisoning were carefully studied for the first time. It was shown in 1932 that nicotine compounds acted slowly as stomach poisons against the walnut husk fly (Rhagoletis suavis (O.S.)).

II. REPELLENTS, OR DETERRENTS

Repellents are not really insecticides, but since they repel insects or deter them from doing damage, their effects and those of insecticides are usually discussed together. Tobacco, because of its strong, penetrating odor, is considered an insect repellent, and as such was first used in 1734.

III. KINDS OF NICOTINE PREPARATIONS

In addition to the previously mentioned tobacco and nicotine preparations there are about 80 more, and the history of nicotine as an insecticide after 1885 pertains mostly to them. In regard to most of them it will not be possible to give the exact dates in which they were first prepared and used, but the first dates to appear in the literature are those that should be noted here.

Nicotine Compounds

From 1900 to 1934, 15 nicotine compounds or salts were prepared and used, and since 1934 several others have been added to the list, although these are not to be considered here. The 15, with the first dates which occur in the abstracts or could be found in notes and the original literature, are as follows: Nicotine sulfate (1900); acetate, lactate, nitrate, and trichloroacetate (1913); resinate (1917); oleate, palmitate, and stearate (1918); tartrate (1919); salicylate (1927); caseinate (1929); tannate (1930); alginate (1931); and bentonite (1934).

Proprietary Nicotine Preparations

The list of proprietary preparations contains 63 trade names, both domestic and foreign, most of which were patented, and many of which seem to have been short-lived. These names did not represent 63 different preparations because one preparation occasionally had two names or one name was later substituted for another. Gold leaf Tobacco Extract (1885), which was apparently the first of the proprietary preparations, was later called Black Leaf Tobacco Extract. From 1885 to 1900, 12 other preparations, including some important dips, were put on the market. In 1892 the first standardized nicotine extract, called Rose Leaf, was placed on the market.

It contained slightly less than 3 percent of nicotine and for many years was more efficient and more widely used than any other form of nicotine. During the next decade 11 more preparations were introduced, half of which proved to be excellent insecticides. A few of these are still being used. In 1908 a patent was granted covering a method of producing a concentrated solution of nicotine sulfate containing as much as 40 percent of nicotine. This sulfate was first called Nico-Sul, but in 1910 it was placed on the market under the name of Black Leaf 40. From 1911 to 1920 about 22 additional proprietary insecticides were introduced, three-fourths of which were foreign. A new type of nicotine-bearing dust, called Nicodust, was first placed on the market in 1920. From 1921 to 1934, 16 more trade names were added to the list. Those most frequently found in the literature include Nico-Fume Fumigating Powder (1922), Vapona (1933), Black Leaf 50, and Black Leaf 155 (1934).

Other Nicotine Preparations

In America dependence has been largely upon the proprietary preparations, but in Europe, particularly in France and Germany, the proprietary products seem not to have been widely used, chiefly because the preparation of nicotine insecticides was controlled by the government. The State factories of France in 1909 prepared ordinary tobacco juice and titrated juice for the agriculturists. The nicotine content of the former depended on its density which, since 1882, was determined by a hydrometer in degrees Baume. The titrated juice, containing sulfates of nicotine and sodium and organic salts, with a nicotine content of 10 percent, was sold as titrated nicotine. In 1924 the French Government issued nicotine in three forms--ordinary juice, an extract containing nicotine sulfate, and condensed juice (a mixture of the other two).

IV. HOW NICOTINE KILLS INSECTS

A little casual information on the physiological effect of nicotine is to be found in numerous papers from 1895 to 1934, but only a few studies were originally planned to determine how nicotine kills insects. A few other papers give additional information which is probably correct but not supported by experiments. It was the fundamental information on this point that led to the preparation and use of nicotine dust.

The symptoms of nicotine poisoning in the experiments with bees in 1916 were divided into three stages. First, bees that had eaten nicotine soon became abnormal in behavior, and the legs and wings were partly paralyzed. Second, the paralysis progressed from partial to complete, the hind legs and hind wings usually being the first to be completely paralyzed, then followed the middle legs and front wings, and finally the front legs. Third, the bees were apparently dead except for slight movements of the head appendages, legs, and abdomen. Regardless of how nicotine is applied, it seems to kill by motor paralysis; that is, it first affects the nerve centers that control muscular movement. Its action on the motor centers causes complete paralysis, which is supposed to be brought about by absorption of the nitrogen atom of the poison by the nitrogen-fat compounds that make up the nerve tissue, with the result that further absorption of oxygen by the cells is stopped and the insect is killed. Since 1916 the word "paralysis" has been repeatedly used in connection with the effects of various insecticides, but incorrectly, perhaps in most instances, because there are very few insecticidal nerve poisons.

Until recently it was thought that nicotine spray solutions and dusts passed into the spiracles and caused death by suffocation. It is now known that spray solutions, without soap or other spreader, do not pass through the spiracles into the tracheae. If they contain a spreader, however, they do pass into the tracheae, although their presence inside the insects does not necessarily cause death. Only nicotine vapor from spray solutions, exhalations from nicotine dust, tobacco powder, or from dried films of spray solutions, and fumes from burning tobacco pass far into the tracheae and are widely distributed to all the tissues, particularly to the nerve tissue, which is the first to be affected fatally.

V. KINDS OF ANIMALS AGAINST WHICH NICOTINE WAS EFFECTIVE

According to the literature prior to 1934, nicotine was effective and had been recommended against only those organisms having soft bodies and others of minute size, such as mites, thrips, aphids, psyllids, leaf-hoppers, crawling scale insects, capsids, lacebugs, lice on poultry, midges, mushroom flies, sawflies, and grapevine moths. These and a few more are discussed somewhat in detail in the following pages, being arranged by orders, families, and species.

INSECTS, MITES, AND TICKS CONTROLLED BY NICOTINE

I. HOMOPTERA

Plant Lice, or Aphids (Aphididae)

Woolly apple aphid.--The application of nicotine has usually effected a satisfactory control of the woolly apple aphid (*Eriosoma lanigerum* (Hausm.)) since 1814, but as this species is covered with a woolly or waxy covering a spreader is always required in the wash or spray solution. This aphid occurs in two forms--the aerial form living on the limbs and leaves, and the root form on the roots. It appears to be universally distributed with the apple tree, for according to the literature it has been treated in 16 countries. In Europe up to the 1890's the wash or spray mixture consisted of tobacco juice, water, and soap, and sometimes sulfur or lime was added. After 1898 concentrated tobacco juice, whose nicotine content was determined by the hydrometer or by titration, was incorporated with water and soap, and it was common in Europe to add alcohol, sodium or potassium carbonate, or even oil. After 1910 it became common practice to use Black Leaf (3 percent nicotine) and Black Leaf 40 with soap or an oil emulsion in the following countries (chronological arrangement): United States, New Zealand, Tasmania, Australia, Korea, and Canada.

Since 1884 tobacco has been used as a remedy for aphids on the roots. The method is to remove the earth around the base of the tree and over the roots, then to put an abundant supply of waste tobacco or tobacco dust against the wood bearing the aphids, and finally to cover the tobacco and roots with earth. The insects in time should be killed or driven away, but this method is often unsuccessful.

Other apple aphids.--In all there are seven or eight species of apple aphids, but as their treatments do not differ widely, only two other species will be discussed here. Since 1867 the apple aphid (Aphis pomi Deg.) has been controlled on apple trees with nicotine in Russia, the United States, Canada, England, Germany, Norway, and Ireland. In the earlier years, Rose Leaf, Black Leaf, Aphis Punk, Nikoteen, Nicoticide (40-percent nicotine), tobacco dust, and home-made tobacco extracts were used in sprays or as fumigants for this aphid. Since 1915, particularly in the United States and Canada, Black Leaf 40 has been used as a delayed-dormant spray, which is generally incorporated with lime-sulfur but sometimes with soap, an oil emulsion, Penetrol, caustic soda, or potassium oleate.

The rosy apple aphid (Anuraphis roseus Baker) appears to have been treated only in the United States and Canada. The best spray used against it was a combination in the proportion of 100 gallons of winter-strength lime-sulfur and 3/4 pint of 40-percent nicotine. The best time for treatment was during the delayed-dormant period just when the buds were beginning to show green. Nicotine has been used effectively against this aphid since 1902.

Peach aphids.--There seem to be four or five species of aphids that infest peach trees. The black peach aphid (Anuraphis persicae-niger (Smith)) has been controlled with nicotine since 1875 in France, and for a shorter time in the United States, Australia, Italy, and South Africa. Before 1910, tobacco decoction, tobacco dust, Black Leaf, and Black Leaf Dip were used. After 1910 it was common to use Black Leaf 40, sheep dips, and other standardized tobacco extracts in kerosene or petroleum emulsion, soap solution, or lime-sulfur. Nursery trees to be transplanted were fumigated or dipped in a nicotine spray mixture. Aphids on the roots of peach trees were controlled by putting tobacco powder on the roots as already described for the woolly apple aphid.

The green peach aphid (Myzus persicae (Sulz.)) infests many plants besides the peach tree. According to the literature, nicotine controlled it on peach^{2/}, potato, tobacco, beet, tomato, pepper, spinach, eggplant, cauliflower, and other vegetables. Nicotine was first used against it in 1908, and it was treated in the United States, Hawaii, Australia, South Africa, Tasmania, France, Italy, England, and India. The most common spray consisted of 40-percent nicotine as the sulfate with soap, but in 1925 carbolated tobacco extract was used in Italy and tobacco decoction with soap in India as late as 1932. Sprouting seed potatoes were fumigated with nicotine and tobacco dust, and this species was most easily controlled on vegetables by using 5 percent nicotine dust.

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In lists of plants the order is governed by the number of references that were cited from the literature.

Spirea aphid.--This species, Aphis spiraeicola Patch, also called the green citrus aphid, is important economically because it infests citrus trees in Florida. It has been controlled with nicotine since 1924. Sprays containing 40-percent nicotine sulfate and soap or sodium oleate were found successful against it, and a 3-percent nicotine dust was particularly recommended.

Black cherry aphid.--Tobacco and nicotine have been used as a control for the black cherry aphid (Myzus cerasi (F.)) on cherry trees since 1872. In Germany it was treated with a tobacco decoction and soap. In the United States the following were used: Black Leaf, Black Leaf 40, or other 40-percent nicotine with or without soap, lime-sulfur, or a miscible oil; a 50-percent nicotine sulfate plus potassium oleate; Nicodust; and lime-nicotine dust. In Russia it was fumigated with tobacco dust or sprayed with a carbolated tobacco emulsion. In Canada it was sprayed with 40-percent nicotine sulfate and lime-sulfur. In France it was treated with a nicotine-soap spray heated to 212° F.

Other fruit aphids.--According to the literature reviewed, many other species of fruit aphids have been successfully controlled with nicotine. These include 1 species on almond, 1 on banana, 2 on citrus, 6 on currant and gooseberry, 1 on fig, 2 or more on grape, 1 on loganberry, 6 on nuts, 1 on pear, 2 or 3 on plum, 3 on prune, 1 on raspberry, and 4 on strawberry.

Bean aphid.--During the past decade the bean aphid (Aphis rumicis L.) has become the standard insect for testing contact insecticides, as it is easily reared and is more easily killed than most aphids. Since 1915 it has been readily controlled with weak concentrations of nicotine. It infests a wide variety of plants, but the literature on nicotine mentions only the following: Beans, beets, tomatoes, artichokes, sorrels, chrysanthemums, Euonymus, and nasturtiums. This species has been treated in the United States, Canada, Russia, Denmark, Algiers, Italy, Czechoslovakia, England, France, and Cyprus. Against it the following have been used: Nicotine (40- and 50-percent); nicotine sulfate (25-, 30-, and 40-percent); nicotine resinate; nicotine oleate; nicotine with sodium oleate, potassium stearate, calcium caseinate, Penetrol, or soap; sulfur impregnated with 2 percent of nicotine sulfate; 5-percent Nicodust; 3-percent nicotine sulfate dust used at the rate of 40 pounds per acre; and almost perfect control on lima beans was obtained by one treatment with a 1.6-percent nicotine dust applied with a self-mixing power duster equipped with a canvas drag which covered the rows for 10 feet behind the duster.

Cabbage and turnip aphids.--The cabbage aphid (Brevicoryne brassicae (L.)) has been controlled with nicotine since 1908 and has been treated in Australia, the United States, Hawaii, Italy, and Canada. Tobacco tea plus soap, carbolated tobacco extract plus sodium carbonate, Black Leaf, Nicofume, Black Leaf 40 with or without soap or miscible oil, tobacco dust, and nicotine dust have been used against it.

The turnip aphid (Rhopalosiphum pseudobrassicae (Davis)), also sometimes called the false cabbage aphid, has been controlled with nicotine in the United States since 1915, 40-percent nicotine sulfate sprays and nicotine dusts having been the most popular controls up to 1934, although more

recently rotenone has become the favored material.

Potato aphids.--There are only two aphids that seriously attack potato plants. One of these, the green peach aphid, has been discussed. The other is the potato aphid (Macrosiphum solanifolii (Ashm.)), which, however, infests plants other than the potato. This species has been controlled with nicotine since 1915, having been mentioned as so treated only in the United States and Canada. The best remedies up to 1934 were a spray consisting of nicotine sulfate and soap, 2- and 3-percent nicotine dusts, and a dust composed of tobacco powder and hydrated lime.

Two other aphids infest potatoes, but they are unimportant, for each was mentioned only three times. The remedy for them was the same as given above.

Pea aphid.--The pea aphid (Macrosiphum pisi (Kalt.)) has been treated in Canada and the United States with tobacco preparations since 1909, but not always successfully. Nicotine sulfate sprays and dusts were often recommended, and the most economical remedy seemed to be a 3-percent nicotine dust applied to rows of peas with a tractor duster having a canvas trailer.

Aphids on other vegetables.--Ten other aphids on vegetables have been briefly discussed in the literature. Tobacco extracts controlled all of them--3 species on sugar beet and lettuce in Europe, 2 each on tomatoes and celery in the United States, 1 each on beans and artichokes in the United States, and 1 on parsnips in Canada.

Hop aphid.--This species, Phorodon humuli (Schr.), had been easily controlled since 1904 with nicotine because it is perhaps the most easily killed of all aphids. It was treated in the United States, Bohemia, Germany, Canada, and England. Against it were used tobacco decoctions, Black Leaf, Black Leaf Dip, nicotine sulfate plus soap or flour paste, 5-percent Nicodust, and 1-percent nicotine dust. The last seems to be the most frequently used in hop yards.

Apple grain aphid.--This insect, Rhopalosiphum prunifoliae (Fitch), has been treated with nicotine in Canada and the United States since 1914. The best remedy was nicotine sulfate plus lime sulfur.

Melon or cotton aphid.--This species, Aphis gossypii Glov., attacks a wide variety of plants, but the abstracts mention only cotton, melons, cucumbers, gourds, and hibiscus, the first two being attacked the most seriously. It is widely distributed, and has been treated with nicotine, first in the United States, then later in Belgium, Nyasaland, Mexico, Chile, Canada, French West Africa, Bermuda, Peru, Russia, and Brazil. In 1901 tobacco decoction, Rose Leaf, Skabecure Dip, and Nikoteen Punk were used against it, but since then Black Leaf, nicotine sulfate solution, free nictines, and various tobacco-fumigating preparations have been used. Nicotine dusts were first tried against it in 1921 and since then they have gradually become more popular. In 1926 a 2-percent dust, applied at the rate of 35 to 40 pounds per acre on melons, was recommended. A dust composed of 94 parts of calcium arsenate and 6 parts of nicotine sulfate solution (40-percent nicotine), applied at the rate of 8 or 9 pounds per acre of cotton, was recommended against the boll weevil (Anthonomus grandis Boh.) and this aphid.

Aphids on conifers.--In the cited literature six species are discussed. All seem to be economically important and they were successfully controlled on spruce, fir, and pine trees with tobacco extract, nicotine (98-percent), or nicotine sulfate solution, each with the addition of soap or an oil; or with nicotine dust. The eastern spruce gall aphid (Chermes abietis L.) was treated in Poland and the United States, C. cooleyi Gill. in the United States, C. piceae Ratz. in Germany and Switzerland, Pineus pini (Macq.) in Norway and the British Isles, the pine bark aphid (P. strobi (Htg.)) in the United States, and P. similis (Gill.) in Nova Scotia and the United States.

Aphids on other trees.--Nine other aphids were controlled with nicotine but were discussed only briefly. These are one species each on balsam, boxelder, Carolina poplar, willow, and tuliptree, and two species each on elms and other shade trees. The species on the willow was treated in France and all the others in the United States.

Rose aphids.--There are at least two species of aphids which infest rose bushes. They are among the aphids most resistant to nicotine but can be readily controlled by applying heavy doses. The most common, the rose aphid (Macrosiphum rosae (L.)), has been controlled with nicotine since 1907 and was treated in Belgium, Germany, the United States, France, and Ireland. Sprays consisting of nicotine sulfate solution and soap and 5-percent Nicodust were recommended as remedies. In greenhouses, fumigation, spraying, and dusting with nicotine preparations were practiced.

The small green rose aphid (Capitophorus rosarum (Kalt.)) was treated only in France and the United States.

Chrysanthemum aphid.--This species, Macrosiphoniella sanborni (Gill.), has been controlled with nicotine since 1911 and was treated in Hawaii and the continental United States. Black Leaf 40 plus soap was the usual remedy.

Aphids on other flowers.--Four aphids infesting other flowers were easily controlled with nicotine. They were on the leaves and bulbs of tulip and iris and on violets in Europe, and on gladiolus corms and geraniums in the United States.

Jumping Plant Lice (Psyllidae)

Apple sucker.--The apple sucker (Psylla mali (Schmb.)) has been controlled with nicotine since 1913. It was treated in Germany, Russia, England, Norway, Ireland, Denmark, Nova Scotia, Sweden, Czechoslovakia, Finland, and Switzerland. The common method was to spray with nicotine or tobacco extract plus soap. In Russia it was successfully controlled by fumigating orchards with tobacco dust mixed with straw.

Pear psylla.--This psyllid, Psylla pyricola Foerst., was first treated in 1842, in England on pear trees, with a tobacco infusion, but the practical control of it seems to date from 1912, when Black Leaf 40 and soap were used. It has been treated in England, the United States, Canada, Germany, Sweden, Czechoslovakia, and Italy with nicotine sulfate solution with soap or lime-sulfur. Various nicotine dusts have also been recommended against it, and a 2-percent dust seems to have been the most economical.

Seven other psyllids have been controlled with nicotine, but these species are not economically important.

Leafhoppers (Cicadellidae)

Potato leafhopper.--This insect, Empoasca fabae (Harr.), is also known as the apple leafhopper or bean leafhopper and as the potato jassid. It has been treated with nicotine since 1908 in the United States and Canada. In most instances nicotine sulfate as either spray or dust was recommended as a satisfactory control, but in a few instances it was inefficient or was not so good as bordeaux mixture, which acted as a repellent.

Grape leafhoppers.--These leafhoppers, Erythroneura comes (Say) and related forms, were treated with nicotine in the United States and Canada. In 1828 tobacco juice was only partially effective and a tobacco fumigation tent on wheels to go over the grapevine trellis was recommended as effective, but was soon discarded as impracticable in vineyards. A more serious attempt to control these leafhoppers was begun in 1910. The nymphs are easily killed with nicotine, but in order to control the adults the dosages must be very strong. Black Leaf 40 with soap, bordeaux mixture, or other substances added to the sprays were used. Nicotine dusts, if unusually strong (7.5 or 10 percent), were generally efficient.

Rose leafhopper.--This jassid, Typhlocyba rosae (L.), was treated in the United States, Sweden, Switzerland, Canada, and Czechoslovakia. It was controlled by using nicotine with soap, Black Leaf 40, and nicotine dust.

Other leafhoppers.--About two dozen other leafhoppers have been controlled with nicotine. The most important of these appears to have been the white apple leafhopper (Typhlocyba pomaria McAtee).

Mealybugs, Scale Insects, and Coccids (Coccidae)

Citrus mealybug.--This coccid, Pseudococcus citri (Risso), has been treated with nicotine since 1911 in the United States, Uganda, Grenada, Russia, Bermuda, and the Philippine Islands. Tobacco dust was inefficient and tobacco extract gave indifferent results. Black Leaf 40 and nicotine were usually effective, but other control methods were available.

San Jose scale.--This scale insect, Aspidiotus perniciosus Comst., has been treated with nicotine since 1901 in Queensland, the United States, India, and Hungary. Nicotine with soap, lime-sulfur, or an oil was usually effective against the immature scales.

Oystershell scale.--Nicotine sulfate with soap or lime-sulfur has been used successfully since 1916 against the young of the oystershell scale (Lepidosaphes ulmi (L.)) in the United States and Canada.

Other coccids.--About 42 other species of coccids were tested with nicotine, and it was found effective against all but 4. The best spray or dipping solution was kerosene emulsion containing nicotine.

Species Belonging to Other Families of Homoptera

Whiteflies.--Seven species of Aleyrodidae were tested with nicotine, which was nearly always inefficient.

Other species.--Thirteen species of the Cicadidae, Fulgoridae, Cercopidae, and Membracidae were treated with nicotine. It was efficient against a cicada, 4 fulgorids, 3 froghoppers, and 1 treehopper.

II. HETEROPTERA

Leaf Bugs, or Capsids (Miridae)

Apple redbug.--Nicotine has been used against Lygidea mendax Reut. since 1911, when sprays containing Black Leaf (1 part to 65), Nico-Fume (1 to 700), and Black Leaf 40 (1 to 816) were found effective. This species, as well as other capsids, is difficult to control, and nicotine is efficient only against the nymphs. Sprays containing 40-percent nicotine sulfate (1 to 800) and soap or lime-sulfur usually gave good control. A 4.7-percent nicotine dust was also said to have been efficient. This important economic species was treated in New York, Ohio, Connecticut, Pennsylvania, and Nova Scotia.

Tarnished plant bugs.--These species, Lygus oblineatus (Say) and L. pratensis (L.), have been treated with nicotine since 1915 in Canada, the United States, Germany, and England. Nicotine in various forms was recommended, but in the United States there was no complete control, although a 5-percent nicotine dust and a nicotine sulfate spray (1 to 200) plus soap were used.

Dark redbug.--Since 1911 Heterocordylus malinus Reut. has been treated with nicotine in New York and Pennsylvania. Dusts were as good as sprays.

Pear plant bug.--This insect, Lygus communis Knight, has also been called the green apple bug and false tarnished plant bug. It infests apple and pear trees in New York, Nova Scotia, and Ontario. Nicotine has been used against it since 1916, a 5-percent dust (2 percent actual nicotine) having been better than nicotine sprays.

Apple capsid bug.--Since 1916 Plesiocoris rugicollis (Fall.) has been controlled with nicotine (usually 98 percent) plus soap in England, Denmark, and Holland.

Other capsids.--According to the literature nicotine was used on a small scale against 32 other capsids. Eight of these species belong to the genus Lygus, one of which, Lygus pabulinus (L.), seems to be an important economic species, for it was treated with nicotine in Ireland, Denmark, England, and Germany.

Lacebugs, or Tingitids (Tingitidae)

Pear lacebug.--The bug Stephanitis pyri (F.) was the first insect to be treated with nicotine, the date and place being 1690 in France. It is a serious pest of pear trees in Europe. In France tobacco fumes and nicotine sprays were used; in Germany tobacco leaves were burned beneath the trees and nicotine solutions were used; in Sweden tobacco extracts were found successful; in Italy phenolated tobacco extracts with soap were recommended; and in Russia both spraying and dusting with nicotine were successful.

Rhododendron lacebug.--This insect, Stephanitis rhododendri (Horv.), appears to be an important pest in Holland and France, where nicotine in various forms was recommended against it.

Other tingitids.--Nine other tingitids were tested once, and nicotine was unsatisfactory against three of them.

Chinch Bug and Other Lygaeids (Lygaeidae)

Since 1913 nicotine has been applied against the chinch bug (Blissus leucopterus (Say)) in the United States and Canada. Black Leaf 40 and soap, nicotine oleate and soap, and nicotine sulfate dusts were the forms mostly used.

Eight other lygaeids were tested, but the records about them are meager.

Squash Bug and Other Coreids (Coreidae)

Nicotine has been applied against the squash bug (Anasa tristis (Deg.)) since 1915 in the United States. It kills only the nymphs, particularly the young ones. One writer recommended 40-percent nicotine sulfate (1 to 600) or a 10-percent Nicodust, whereas another writer said a 3-percent nicotine dust or spray should be used.

Three other coreids are mentioned but there is little information about them.

Pentatomid Bugs (Pentatomidae) and other Heteroptera

Under this heading nine species are mentioned, but no definite statement has been made about nicotine being effective against them.

III. THYSANOPTERA, OR THRIPS

Onion thrips.--Since 1898 this species, Thrips tabaci Lind., has been controlled with nicotine. It was treated in the United States, Sweden, Australia, Canada, Barbados, Bermuda, Germany, Dominican Republic, Maurice, Crimea, and England. Nicotine sprays were mostly used and were usually effective. Nicotine dusts and nicotine tannate were also employed.

Greenhouse thrips.--This species, Heliothrips haemorrhoidalis (Bouché), has been controlled since 1868 with tobacco products. It was treated in France, Germany, Luxembourg, the United States, Argentina, Sweden, Belgium, Brazil, and Italy.

Pear thrips.--This thrips, Taeniothrips inconsequens (Uzel), has been controlled with nicotine since 1909. It was treated in the United States, Canada, and Norway.

Other species of thrips.--About 36 other species were treated with tobacco products, but there are only a few records regarding each of them. Nicotine was effective against most of these, including the grape thrips (Drepanothrips reuteri Uzel), Florida flower thrips (Frankliniella cephalica (Crawf.)), bean thrips (Hercothrips fasciatus (Perg.)), "sugarbeet thrips," red-banded thrips (Selenothrips rubrocinctus (Girard)), and citrus thrips (Scirtothrips citri (Moult.)), but it had little value as a control for the gladiolus thrips (Taeniothrips simplex (Morison)).

IV. DIPTERA

Tobacco products were tried against numerous species of Diptera, and the use of nicotine gave a good degree of control but was not found practical against parasites on cattle because of the toxicity of nicotine to the host. It was effective against the following: Cattle grubs, Hypoderma bovis (Deg.) and H. lineatum (De Vill.); various species of mosquitoes; the pear midge (Contarinia pyrivora (Riley)); the chrysanthemum gall midge (Diarthromomyia hypogaea Lowe); the boxwood leaf miner (Monarthropalpus buxi Lab.); various species of mushroom flies belonging to the Mycetophilidae and Phoridae; and the spinach leaf miner (Pegomya hyoscyami (Panz.)).

V. HYMENOPTERA

With regard to the Hymenoptera, the use of nicotine has been recommended as a control against only the sawflies, the larvae of which are slug-like insects. The following were the species most commonly treated: Apple sawfly (Hoplocampa testudinea Klug), cherry fruit sawfly (H. cookei (Clarke)), and Neurotoma nemoralis (L.).

VI. COLEOPTERA

Tobacco products were tried against numerous species of beetles belonging to many families, but nicotine was found effective against only a comparatively few species. These included several species of flea beetles in Europe, reported long before 1934, and two species of cucumber beetles in America. Nicotine is still used as one of the controls against the latter.

VII. LEPIDOPTERA

Grapevine moths.--According to the literature being summarized, the vine moths, Phalonia ambiguella Hbn.) and Polychrosis botrana (Schiff.), which are serious pests in continental Europe and Northern Africa, were first tested with nicotine in 1870. Prior to 1915 the use of nicotine was the recommended control against both generations of moths, but by 1917 tobacco products were too costly and almost unobtainable because of the First World War, and it became necessary to find a cheap and effective insecticide. By 1925 the use of lead arsenate had become the recommended control against the first generation of these moths while nicotine was still used against the second generation.

Codling moth.--Nicotine was first tried in 1897 against the codling moth (Carpocapsa pomonella (L.)), which is a serious pest wherever apple trees are grown. From this year up to October 1934, inclusive, 133 abstracts in Circular E-392 pertain to the use of nicotine against this moth, although the nicotine was often used in an arsenical spray mixture primarily to control aphids or certain bugs. In 1916 nicotine sulfate was reported in Washington State to have been as efficient as lead arsenate. This report caused considerable experimental work to be done during the next 12 years. In 1928 the Washington entomologists still claimed that nicotine sulfate could be used as a substitute for lead arsenate in the second and third cover sprays, although this combination was somewhat less effective.

Nicotine in combination with oil emulsion was apparently first tried against the codling moth in 1928. There are 70 abstracts which discuss this combination. It was generally agreed that nicotine sulfate combined with mineral-oil emulsion was a good substitute for lead arsenate. The following statements give some of the details: In 1929 and 1930 this combination proved as effective as the arsenate. The combination of oil (1 to 100) and nicotine sulfate (1/2 pint to 100 gallons) gave a control of the codling moth equal to that of 1 pound of lead arsenate to 50 gallons of water. In 1931 reports from nine investigators were compared. Some said that the oil-nicotine combination gave results equal to those obtained with lead arsenate, while others did not get such good results. It was as effective as the arsenate in preventing entry into the fruit and was decidedly more effective than the arsenate in preventing "stings." In 1932 the nicotine-oil spray combined both ovicidal and larvicidal properties for the codling moth and also controlled aphids and mites. This combination, used for several years in the late cover sprays, always gave excellent results which were approximately equal to those of lead arsenate. In 1933 the trend of results slightly favored lead arsenate. In 1934 the consensus of opinion was that lead arsenate was superior, but nicotine-oil was very close to it and was the most promising substitute.

There is 1 abstract about nicotine bentonite, 2 about nicotine dust, 3 about nicotine oleate, and 25 about nicotine tannate. The last gave extremely variable results, ranging from no good or not satisfactory to better than lead arsenate for use against the codling moth.

Other moths.--Nicotine was tried against other moths and it was effective against many of them but was rarely recommended as a control because there were usually other better and more economical insecticides.

VIII. ACARINA

Red spiders.--The common red spiders (Tetranychus spp.) have been controlled since 1898 with nicotine combined with other materials such as oil, strong soap, or lime-sulfur. They were treated in Germany, Switzerland, Bohemia, Australia, the United States, Argentina, England, Canada, Russia, and Italy.

European red mite.-- This species, Paratetranychus pilosus (C. & F.), was successfully treated in most instances with nicotine in Sweden, Denmark, the United States, and England, but the nicotine was added to other materials.



Cyclamen mite.--This mite, Tarsonemus pallidus Banks, was controlled in the United States by using Black Leaf 40, nicotine oleate, and tobacco dust.

Other mites on plants.--There are a few records on about two dozen other species of mites, but not all of them report successful control with nicotine.

IX. EXTERNAL PARASITES ON ANIMALS AND MAN

The mites and ticks, which are not insects, belong to the Acarina, the sucking lice to Anoplura, the biting lice to Mallophaga, the fleas to Siphonaptera, and the flies to Diptera. The writer was unable to use many of the abstracts in E-392 because they discuss lice without giving their scientific names. The word "lice" includes the Anoplura, the Mallophaga, and the sheep louse or tick, which is really a fly.

Mites.--Nicotine sulfate was effective against Liponyssus sylvium (C. & F.), the chicken mite (Dermanyssus gallinae (Deg.)), the mites Psoroptes communis Fuerst and P. ovis Her. on rabbits and sheep, and the mange mites Sarcoptes scabiei Deg., S. equi Gerl., and S. suis Gerl. on cattle, horses, and dogs.

Ticks.--There is very little information on the use of nicotine on ticks. Nicotine was apparently effective against only the immature stages on cattle and sheep. It may be applied to the vegetation and about kennels to kill the newly hatched ticks.

Sucking lice.--Five species are mentioned. Nicotine fumigation was effective against the body louse (Pediculus humanus corporis Deg.). Nicotine is not recommended because of its possible toxic features to humans or animals.

Biting lice.--Nicotine was used satisfactorily against four out of five species.

Fleas.--Only one species was mentioned by scientific name. Nicotine was usually effective against fleas when it was sprayed on vegetation and basement floors.

Flies.--Nicotine was also effective against the sheep louse or tick (Melophagus ovinus (L.)) and the pigeon fly (Pseudolynchia canariensis (Macq.)) in low concentrations, but at least two dippings are required. Because of its absorption and subsequent toxic qualities it is not favored.